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Engaging People with Energy Efficiency: A Randomised Controlled Trial Testing the Effects of Thermal Imaging Visuals in a Letter Communication

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Abstract: The study tested the effect of adding visualisations to a communication to engage householders with an energy efficiency programme. External wall insulation is an appropriate way of insulating homes, yet take-up is low. Householders may be unaware of the heat loss from uninsulated walls. In earlier research, seeing thermal images prompted the uptake of simple energy efficiency actions amongst householders. Thermal images were added to a standard letter to visualise heat transfer from a home before and after external wall insulation had been installed. A randomised controlled trial tested three types of letter (standard, standard plus thermal image showing problem, standard plus thermal images showing problem and solution) in 5483 UK households. The target outcome was the rate of telephone enquiries after exposure to the letters. Enquiry rates were low (1.6%) and did not differ between letter type. We discuss the null effect in relation to the target action (external wall insulation), the manner of presentation of the visuals (mass communication, letter through the door) and the ingredients of a persuasive intervention. Findings suggest that taking a key ingredient from an intervention and applying it in a different context may result in the loss of its impact.

Keywords: social psychology; behaviour; interventions; visualisation; energy demand; households; persuasion; thermal imaging; SDGs 1, 7, 11 and 12

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1. Introduction

1.1. The Role of Psychologists in the Interdisciplinary World of Energy Efficiency

The environmental challenge of managing global energy resources is an important area for psychologists. Energy use is a core part of global plans to reduce greenhouse-gas emissions whilst also meeting the challenge of ensuring energy security around the world and bringing energy to those who need it. Energy efficiency is an important factor in reducing emissions [1] and is a key area where psychologists can apply the tools and knowledge of their discipline [2]. Human choices and behaviour affect energy consumption levels, the success of appeals to mitigate consumption and the uptake of energy efficiency measures. Energy efficiency is an environmentally significant behaviour [3] with a strong potential for communication and behaviour change programs to be used to reduce energy demand. Actions, such as insulating a home, are behaviours which feature high behavioural plasticity and high potential energy savings [4,5]. Taken together, this yields an opportunity for substantial reductions in energy use for modestly expensive or modestly coercive interventions. This paper aims to address calls to embed evaluations into environmental

programs in order to analyse their success and so inform the feedback loop for the next round of research on psychological interventions [6,7]. The study reported in this paper also employed a multidisciplinary team of architects, building physicists, psychologists and local government, in response to the call for psychologists to work alongside other disciplines to address environmental challenges [2,8,9]. Clayton Devine-Wright, Swim, Bonnes, Steg, Whitmarsh and Carrico [2] argue that psychologists have an important role to play in addressing real world problems and in collaborating in interdisciplinary research that focus on specific environmental problems [2] (p. 199). The study presented in this paper is set in this context. Its main research focus is how to communicate building physics related concepts in order to engage householders better with energy efficiency programmes.

1.2. Engaging Householders with Energy Efficiency Actions

Engaging householders with energy efficiency schemes is not straightforward. Although they would benefit from measures such as loft insulation and solid wall insulation, take-up is often low [10–12]. Further, of all of the available energy efficiency schemes, the take up of schemes that promote and sometimes finance external wall insulation, has been particularly low in the UK [12] even though addressing the problem of cold homes and fuel poverty is a government priority [13,14]. This slower penetration of energy efficiency investments (than might be expected, based on economic assumptions) is often termed the "energy efficiency paradox" [15,16]. Several factors have been identified that explain the low uptake; complex funding schemes, the requirement of a financial contribution from the householder, interest rates on some schemes that work on a loans-basis [12]. These types of contextual factor can be significant barriers and deter householders from taking energy efficiency actions [7,17]. Additionally, householders 'remain stubbornly resistant to..... making major structural changes' [18] (p. 19) and external wall insulation is a major retrofit. However, psychological/behavioural factors also impede the take up of efficiency behaviours [14,19]. Some people may not be aware that a problem exists and even on becoming problem aware they may not know what to do about it [20]. Similarly, trust in the action and a belief that the action will indeed make a difference are psychological predictors of pro-environmental choices and the perception of contextual barriers. In this sense, psychological and contextual barriers are interlinked [3,7]. For example, a change in problem awareness and knowing what to do about energy and heat loss in a building may provide more positive attitudes towards overcoming the contextual barriers to action. A focus on the 'problem' and what to do about the problem might be especially important in the context of home heating. Householders may know that their home feels cold, but they may not be fully aware of the 'problem', the process by which this is happening, nor the degree of heat egress through the walls. Largely this is impossible to see or experience directly. Therefore, the link between the consequences of the problem (i.e., a cold home) and technical aspects such as wall construction, or behavioural aspects such as airing practices, may not be direct. The householder could, for example, blame the heating system for not operating at a high enough temperature. Therefore, any communication which aims to motivate people to take energy efficiency measures such as adding insulation might be enhanced if it includes specific and powerful communication about the 'problem' (a visualisation of heat leaving the walls of the house), and also the 'solution' (a visualisation of an insulated home after specific measures have been put in place). Hence the way in which energy efficiency schemes (and the benefits of the actions) are communicated is important [12]. The point at which people are introduced to a scheme may be the only contact with the individual and therefore may be a critical moment in addressing psychological or contextual barriers. The standard available medium that communicates such energy efficiency schemes to specific communities is often a letter direct to the householder's address. Standard letters usually include text which explains the offer, and may be accompanied by images to attract attention, communicate and complement the text. The present research tested the effect of adding specific message-related images to a standard letter communication. The images were designed to communicate the 'problem' (that of

the performance of uninsulated homes) and a 'solution' to that problem (the effect of adding insulation).

1.3. Energy Efficiency and External Wall Insulation in UK Homes

Energy generation and use are large contributors to climate change due to the associated carbon emissions from the use of fossil fuels. The energy used within the domestic home sector accounts for 25% of UK carbon emissions with 75% of that used to heat the home and provide hot water [21]. In the UK, space heating can account for as much as 66% of a home's energy use. In part this is a factor of the legacy of building types in the UK; it has 'one of the oldest and least efficient housing stocks in Europe' [22] (p. 38). The condition of UK homes and their energy efficiency can be gleaned a little by looking at the UK SAP ratings (Standard Assessment Procedure). Up to 80% of UK solid wall buildings have a SAP rating less than the UK mean and 31% of UK total stock are solid wall dwellings [23]. Homes built of single wall or solid wall constructions are a particular problem. These homes can feel cold, with 60% of solid wall dwellings having failed the decent homes standards for adequate thermal comfort [24]. The Energy Saving Trust predicts that UK dwellings lose 45% of their heat (heat egress) through the walls [25]. They also exhibit high levels of condensation and mould. As a guide, those UK homes with a SAP rating of 30 or below are classified as Category One hazard for cold, with implications for the health of the occupants, mainly the increased risk of cardiovascular and respiratory disease [22,26]. Solid wall construction homes make up a part of the sector of homes known as 'Hard to treat' or 'Hard to heat', [27] (p. 2) being unsuitable to receive the 'staple' offer of energy efficiency measures such as loft insulation, cavity wall insulation, and improvements to the heating system. One solution to reducing heat egress is the installation of external wall insulation [28]. The Energy Saving Trust predicts that adding wall insulation to a solid wall can reduce bills of a typical mid terraced-home and reduce carbon emissions [29]. Therefore, this paper focuses on the effect of communicating this 'solution': to insulate solid wall homes with external wall insulation. The installation of external wall insulation to solid wall homes could play a large part in reaching the goal of warmer homes, improved health outcomes, reduced fuel poverty and reduced kgCO2 emissions [22,30]. However, the role of the person (householder) in achieving these goals cannot be underplayed; in most circumstances, they have to agree to the installation. The householder is a crucial part in achieving energy efficiency in their home, through the decisions and choices they make. Homeowners, however, may be better placed to respond to interventions that promote energy efficiency measures, being the decision makers regarding large investments in the home. For the purpose of this study and paper, we define 'householder' as the person ordinarily resident in the property, who may or may not be the homeowner, responsible for more substantive changes.

1.4. Visualising Energy and Heat Loss

Problem awareness is one factor which predicts the take-up of pro-environmental actions in general [20] (and in external solid wall insulation in particular; Hansford [30]). Being aware of the consequences of the problem is a further factor in promoting behaviour [3,20,31]. Additionally, having awareness of the efficacy of mitigating action [32] is important. These beliefs play a role in directing behaviour, and communications should cover these factors. However, how these factors are communicated could play a crucial role, for example through visualisation.

The invisibility of energy generally (and heat egress in specific) is a particular challenge to achieving energy demand reduction. Many scholars have identified the invisibility of energy as a key barrier to energy efficiency actions, with calls to increase general energy literacy and make energy more visible [33,34]. Energy (and energy efficiency by association) is a relatively intangible concept [35]. It is difficult to directly experience any energy (heat) that is being wasted through the walls and material of the buildings we inhabit. Shove [36] refers to the 'act of faith' that a householder takes to action energy efficiency measures.

Therefore, when people are asked to insulate their homes, this invisibility can prevent a full realisation of energy saving potential. Within this context, using images may be important in overcoming some of the barriers posed by the invisibility of energy.

Previous research has shown visualisation to be powerful when communicating the problem and possible solutions in the context of climate futures. When householders viewed images (albeit on a cinema style screen) of their changing local neighbourhood under various future climate change scenarios, they reported increased concern, a raised awareness of the mitigation responses and an increase in the belief that the actions they took would indeed make a difference [37]. It is known that images can stand in for or be synonymous with an issue [38] and an image can communicate a complex issue more readily than standard alternative communications. Images are particularly helpful in aiding the conceptualisation of ideas which are difficult to imagine or which are naturally invisible [39,40]. In the health domain, using images to communicate the health 'problem' or consequence of smoking (images of blackened lungs or the effect of smoke damage) have been successful in promoting smoking cessation [41–43]. However, people's responses to images are always subject to individual interpretation. Images are never neutral, being viewed through the lens of the viewer's beliefs, knowledge and prior experiences [38].

In the energy/heat context, studies have 'made heat visible' using thermal imaging and have reported a favourable response by householders to the visual nature of the images [44]. Indeed, making heat loss visible can attract attention in the energy domain [45–47]. Research into the behavioural effects of viewing such images of one's own home found that householders were more likely to take the energy saving actions visible in the images, compared to those actions not visible in the images, and were almost five times more likely to draught proof compared to those householders who received an energy audit and home visit without any images [48]. The thermal images seemed to announce new energy saving actions for the householder to consider. Further, simple and uncomplicated energy efficiency measures were promoted by viewing the images, when those images were of one's own home [48,49]. Thermal images can communicate the 'problem' of heat egress/cold air ingress (such as the location of draughts in the home), and by inference can announce the consequence of addressing this problem through energy efficiency actions (see Figure 1). Giacomin and Bertola [50] argue that thermal images also enable learning about the physics of the energy system.

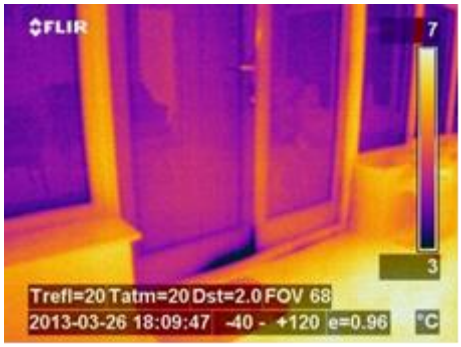


Figure 1. A draught or cold air ingress at the centre-right of the patio door is clearly visible as a dark, cold patch on the thermal image; note the temperature scale on the right-hand side.

Thermal images make heat visible by observing infrared radiation, which when converted into temperature readings enables the visualisation of differences in surface temperature. One example would be temperature differences across a house wall. It is then possible to qualitatively infer areas of unexpected heat loss from a building, or compare one building with another in terms of heat loss. These images provide information about heat (which is hard to communicate in text form) and can visually communicate an energy efficiency problem (e.g., the draughty door in Figure 1). The images have the potential to help householders understand and identify the 'problem' of heat loss and the effect of

energy saving actions (the solution), such as installing external wall insulation (our target efficiency measure here).

However, in previous studies, thermal images were employed as a highly personalised intervention, taking the camera to image the homes of the householders. This type of more intensive intervention involves personalisation and tends to be more successful in achieving energy saving behaviours but also requires more resources in terms of time, personnel and funding [51]. The question remains about the conditions under which thermal imaging interventions are effective [52] and whether using less personalised thermal images will also promote the uptake of energy saving actions and thus allow broader rollout. A recent study [53] began to investigate this question and found mixed results. Overall, thermal images were best when tailored, promoting a range of responses (increased behavioural intention, a vivid and intrusive recall of the energy efficiency communication, increased engagement and an increase in the belief that occupants would benefit from taking draught proofing measures in their home). However, adding typical (non-tailored) thermal images also offered some benefits over text only communications about energy efficiency. Typical thermal images were better than a text only communication in terms of promoting vivid recall of the communication, promoting the belief that the occupant was at risk of experiencing cold draughts, and encouraging behavioural change intentions.

1.5. Communications That Promote Behaviour

Another approach, rather than a report or personalised series of images, is using typical thermal images in marketing materials, mailshots or letters. Thermal images have been used in marketing to portray the effect of taking energy efficiency actions, for example, improved glazing (https://www.everest.co.uk/double-glazing-windows/triple-glazing-windows/triple-vs-double-glazing/, accessed on 21 March 2021). However, as mentioned previously, letters are often the medium through which energy schemes are offered to the householder, as an antecedent [54,55] to promote the take up of a scheme. A recent systematic review found that mailings (e.g., letters, postcards) as a medium of communication can effectively promote water conservation [54]. Letters through the post have been successful in promoting energy conservation when they provided feedback about energy consumption [56] especially alongside other community activities [57]. Letters to UK householders were used to announce a loft insulation scheme; however, the response rate to this mailshot letter (0.05% of householders responded) was very low [10]. Previous research has shown that including images in the design of letters has been effective in achieving desired behaviours in domains outside of energy efficiency. In the UK, the Behavioural Insights Team has experience in evaluating this approach and in using objective behavioural measures, such as calling to express an interest or registering for an online service. Images were combined with personal information in the context of a letter reminding drivers to pay overdue car tax. Inserting an image of the taxable car into the letter led to an increase in payment rate from 40% to 49% [58]. This approach used images in two ways; firstly, to attract the attention and, secondly, to make the consequence of inaction personal and specific to the car owner.

As has been alluded to earlier in this paper, making the message of energy efficiency personal and specific to the householder is important in the energy domain too. In the context of letters, a letter which shows an image of a house that looks very similar to the one lived in by the recipient would be expected to attract the attention more than a dissimilar house. The rationale here is that personally relevant information has been shown to be more powerful in promoting attention to interventions and energy savings [51,59,60]. Further when knowledge is specific to a behaviour it is also more influential in causing that behaviour [61–63]. Therefore, interventions that are personally relevant and specific to the household, providing information about specific behaviours, might be more effective in triggering energy saving behaviours.

Using a letter approach, which employs thermal images to communicate heat loss in a house 'like yours', might attract the attention of the householder. It might be a medium

through which to communicate the 'problem' and a 'solution' by visually portraying the heat egress in one image and the efficacy of insulating the walls of the house in another. However, thermal image letters and tax demand letters are not directly comparable interventions. As explained earlier, energy efficiency behaviours are affected by significant external barriers, which is not true to the same extent for the payment of car tax. Similarly, there are significant barriers to installing external wall insulation; it is a complex energy saving measure (unlike draught proofing) and the schemes that provide external wall insulation can require additional spending by the householder and be complex to administer (at least in the eyes of the householder). The car tax letter also differs from the thermal image letter as it communicates a second message, that the government has accurate records about the car and will act on that information, which aligns with the financial penalty of not paying the tax. Failure to take up a scheme to insulate walls has no similar penalty. Finally, the compliance rates/uptake in these two domains are historically different. The standard response rate to a letter requesting an overdue car tax payment was 40% [58] whilst the uptake rate of a recent scheme to insulate lofts was 0.05%. The uptake of external wall insulation is a complex energy saving behaviour affected by external and contextual barriers, experiencing low response rates [12].

1.6. Rationale

This study tested whether adding thermal images to a letter of invitation would increase interest in an external wall insulation scheme. The letter informed householders of the wall insulation offer and announced a grant towards the cost. To test the effect of adding thermal images, three different letters were used: (1) a standard, text only letter (STD), (2) a letter with one thermal image showing the problem (house without insulation; PRB) and (3) a letter with one thermal image showing the problem and one thermal image showing the solution (house without and with insulation; PRB + SOL). All householders received a thermal image relevant to their own house type (concrete or Victorian build). 'Victorian' refers to houses built during the Victorian era in English history that comprised most of the 19th century, and both the aesthetic, building practices and materials that were common at that time. The key research question was whether the type of letter would influence householders' propensity to call up to enquire about the scheme. An objective behaviour measure was used as simply whether the householder, after receiving the letter, made a phone call to enquire about the offer. A secondary question was whether type of house and ownership would affect the propensity to enquire. Additionally, a small qualitative study explored householders' reactions to the thermal images included in the letters.

2. Materials and Methods

2.1. Participants

This work was completed with full ethical approval from the Faculty of Science and Technology Human Ethics Committee at University of Plymouth. A sample of householders in Plymouth in the South West of the UK were the participants (n = 5483). This was an opportunity sample consisting of homes where householders were offered a grant to install solid wall insulation. These homes were all of solid wall construction, located in streets where neighbouring council owned homes were already undergoing a retrofit of external wall insulation. The City Council wanted the retrofit to be offered to the neighbouring homes. Therefore, letters were sent in the mail to announce the grant availability. Most of the cohort owned their own homes (n = 3826), others lived in the rented sector (n = 205) or owned their ex council or housing association home (n = 1445) with seven homes being of unknown ownership. All householders were eligible to receive a grant to improve the energy efficiency of their homes by installing external solid wall insulation. Householders lived in either Victorian built homes (n = 2072) or homes of concrete construction (n = 3411) and had walls without cavities which were suitable for external wall insulation. This scheme was announced to the householders using a letter through the door of the property (mailshot addressed "to the householder"). The cohort of houses had already received a

mailshot earlier in the year; the letter approach described in this paper was their second contact, i.e., to remind them of the scheme. The sample of house addresses was randomly allocated to one of three conditions (STD, PRB or PRB + SOL, see Figure 2a–e). Not all letters could be sent out at the same time, and so they were sent out over a number of days. Participating households were therefore assigned to a day/treatment pair at random, with randomisation stratified by the type of house (Victorian or Concrete).

The local scheme was coordinated in conjunction with the City Council and a local cooperative community energy group (http://www.plymouthenergycommunity.com/, accessed on 21 March 2021), supported by a successful £3m bid by Plymouth City Council to Department of Energy and Climate Change (DECC) to deliver its Green Deal for Communities programme. This programme enabled the council to offer large grants to householders to cover the cost of solid wall insulation. There was no upfront fee, though a £500 deposit was required for works to proceed. The grant offered up to £5400, subject to assessment, technical survey and eligibility criteria. The householder needed to ring a phone line to claim the grant and book a survey. (The Energy Savings Trust quote the approximate cost of solid wall insulation, based on a typical semi-detached house in the UK, as approx. £10,000 [25]).

On day 12 of the study, after 12 days of sending letters to householders, it was noticed that a cohort of the Victorian homes had been duplicated in the original database and so 741 householders had received two letters in error. At this point, because these homes received not only two different letter types but in varying combinations and order of receipt, the 741 homes who had received two letters were removed from the main sample of householders along with the duplicate addresses, resulting in 4742 homes remaining in the sample. As this duplication occurred exogenously, these observations are excluded from analysis without loss of causal identification.

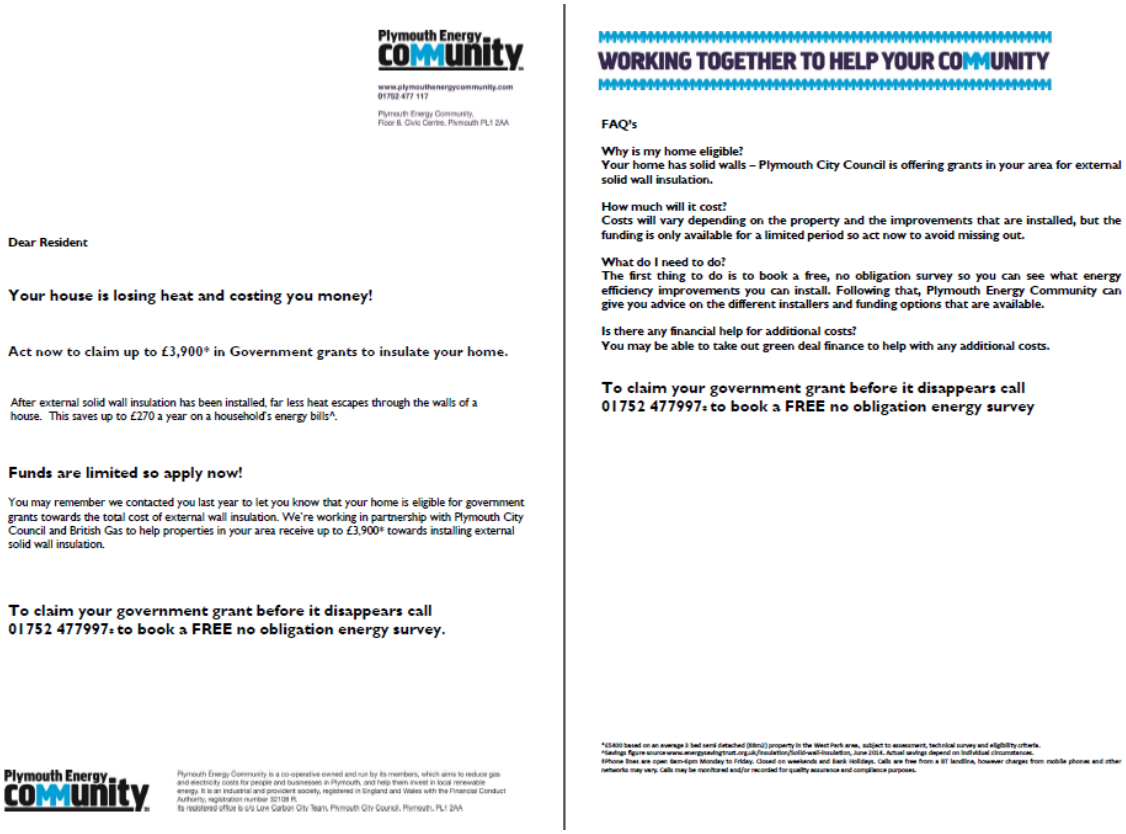
2.2. Design, Measures & Materials

This study employed a between groups design with type of letter as the key independent variable (text letter with no image (STD), a without insulation thermal image (PRB) and with and without insulation thermal images (PRB + SOL)) and house type and ownership as secondary independent variables (Victorian build or Concrete build; owner occupied, rented, council/housing association owned). The study measured one primary categorical outcome, the propensity of the householder to follow up the letter (mailshot) by telephoning the number included in the text of the letter, coded as yes or no (see Figure 2a–e).

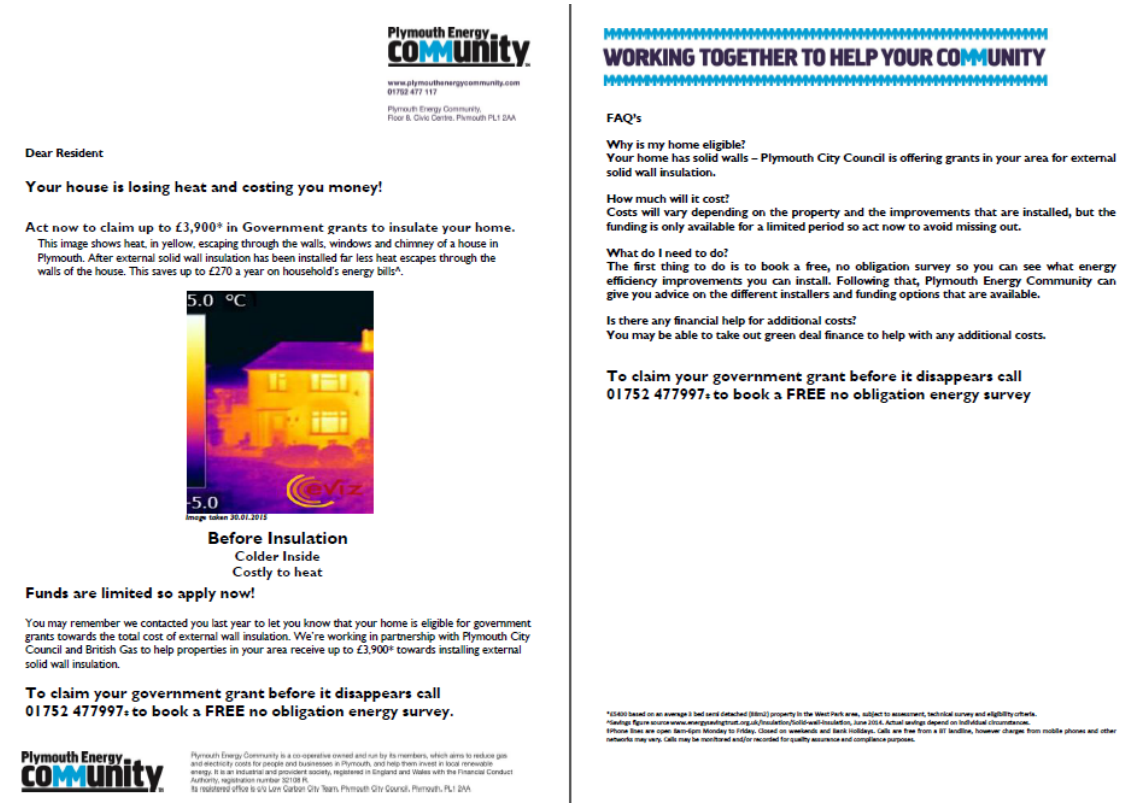
2.3. Procedure, Thermal Imaging Protocol

The study started in January 2015, with a thermographer capturing the thermal images to be included in the letters. The thermographer had a Level 2 certificate in thermography (as defined by the United Kingdom Thermography Association, UKTA [64–66]). In accordance with guidance from the UKTA [64] and the British standard for qualitative thermography [66], houses were imaged on cold, dry nights, which had cloud covered skies and low wind speeds [67]. These conditions increase the likelihood of dwellings being heated, which is desirable for good thermal images. A FLIR T335 thermal camera was used to capture the images, which were displayed using the iron bow colour palette. We imaged 10 other semi-detached or terraced homes before selecting two Victorian and two Concrete houses as providing the best visualisation.

These were imaged from the outside of the building, to provide with and without insulation images. To achieve this, homes which had already had solid wall insulation installed were used along with an uninsulated house next door. This ensured maximum possible parity for comparison as the images were taken under the same external weather and temperature conditions on the same night. Note that the without (PRB) images were the same in the two thermal imaging conditions.



(**a**)



(**b**)

Figure 2. *Cont*.

Plymouth Energy COMMunity

www.plymouthenergycommunity.com
01752 477 117

Plymouth Energy Community,
Floor 8, Civic Centre, Plymouth PL1 2AA

Dear Resident

Your house is losing heat and costing you money!

Act now to claim up to £3,900* in Government grants to insulate your home.

This image shows heat, in yellow, escaping through the walls, windows and chimney of a house in Plymouth. After external solid wall insulation has been installed far less heat escapes through the walls of the house. This saves up to £270 a year on a household's energy bills^.

Before Insulation
Colder Inside
Costly to heat

Funds are limited so apply now!

We're sending you this letter because your home is eligible for government grants towards the total cost of external wall insulation. We're working in partnership with Plymouth City Council and British Gas to help properties in your area receive up to £3,900* towards installing external solid wall insulation.

To claim your government grant before it disappears call 01752 477997± to book a FREE no obligation energy survey.

Plymouth Energy COMMunity

Plymouth Energy Community is a co-operative owned and run by its members, which aims to reduce gas and electricity costs for people and businesses in Plymouth, and help them invest in local renewable energy. It is an industrial and provident society, registered in England and Wales with the Financial Conduct Authority, registration number 32108 R.
Its registered office is c/o Low Carbon City Team, Plymouth City Council, Plymouth, PL1 2AA

WORKING TOGETHER TO HELP YOUR COMMUNITY

FAQ's

Why is my home eligible?
Your home has solid walls – Plymouth City Council is offering grants in your area for external solid wall insulation.

How much will it cost?
Costs will vary depending on the property and the improvements that are installed, but the funding is only available for a limited period so act now to avoid missing out.

What do I need to do?
The first thing to do is to book a free, no obligation survey so you can see what energy efficiency improvements you can install. Following that, Plymouth Energy Community can give you advice on the different installers and funding options that are available.

Is there any financial help for additional costs?
You may be able to take out green deal finance to help with any additional costs.

To claim your government grant before it disappears call 01752 477997± to book a FREE no obligation energy survey

*£3400 based on an average 3 bed semi detached (88m2) property in the West Park area, subject to assessment, technical survey and eligibility criteria.
^Savings figure source www.energysavingtrust.org.uk/insulation/solid-wall-insulation, June 2014. Actual savings depend on individual circumstances.
±Phone lines are open: 8am-6pm Monday to Friday. Closed on weekends and Bank Holidays. Calls are free from a BT landline, however charges from mobile phones and other networks may vary. Calls may be monitored and/or recorded for quality assurance and compliance purposes.

(**c**)

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Before Insulation
Colder Inside
Costly to heat

After Insulation
Cosy Inside
Saves up to £270 on energy bills a year^

Funds are limited so apply now!

You may remember we contacted you last year to let you know that your home is eligible for government grants towards the total cost of external wall insulation. We're working in partnership with Plymouth City Council and British Gas to help properties in your area receive up to £3,900* towards installing external solid wall insulation.

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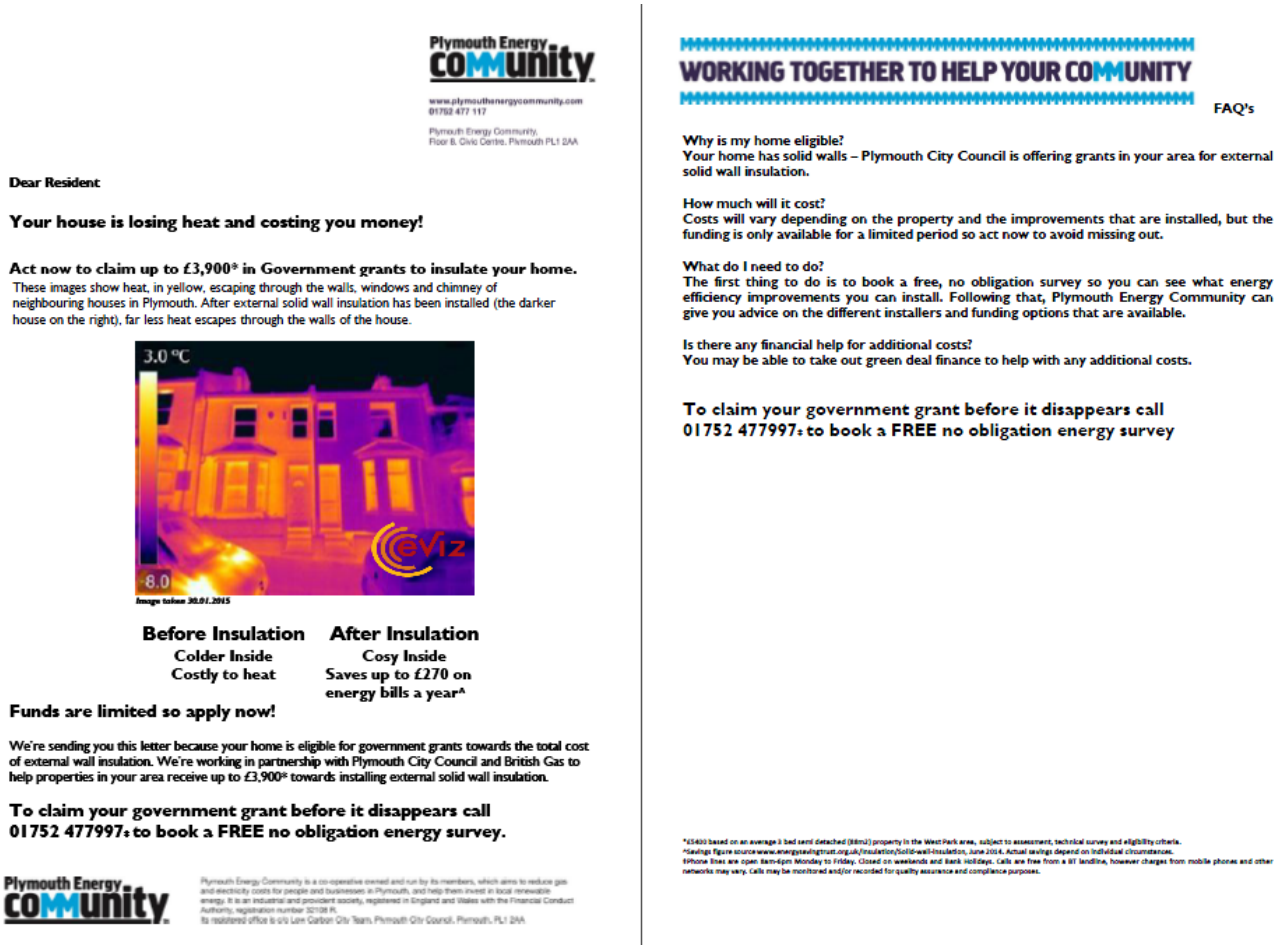
(**d**)

Figure 2. *Cont.*



(**e**)

Figure 2. (**a**) Standard text letter with no image STD (all house type). (**b**) Without insulation thermal image letter (PRB)—Concrete house type. (**c**) Without insulation thermal image letter (PRB)—Victorian house type. (**d**) With and without insulation thermal images (PRB + SOL)—Concrete house type. (**e**) With and without insulation thermal images (PRB + SOL)—Victorian house type.

During March and April 2015, letters were mailed to houses in batches over 20 working days. Letters were enclosed in envelopes, addressed 'To the Householder'. When a householder telephoned the call centre to enquire about the offer, the house number, street name and postcode was logged at the call centre. This log was later matched to the type of letter that was sent to this address, using an excel spreadsheet.

A record of enquiries to the call centre began on Day Two of the mailshot (i.e., day one was the day that the letters were posted, which would have been received from day two onwards), and the number of households who called up was counted on Day 64 of the Study. These data provide the basis for the results reported in this paper.

2.4. Qualitative Follow-Up Study

A small qualitative study was also used to explore additional householders' reactions to the thermal images included in the letters. After the mailshot study ended, community events were held in local centres where householders (who were eligible for the scheme) could drop in and ask questions of the insulation installers and sign up to the scheme. At two of these events, 15 householders were asked to look at the three letters that were appropriate for their house type. These householders would not have received the letters. They were asked if they would mind assisting in how energy schemes, such as this one, should be communicated. After agreeing to help, they were shown the three letters and

asked an open question: to comment on which letter would be more informative and which was their preference.

3. Results

3.1. Letter Type

In total 77 out of 4742 homes called up to enquire about the scheme (an enquiry rate of 1.6%). Chi-square analyses ($\chi 2$) were used throughout to test for any relationship between numbers of enquiries about the grant scheme and letter type (and by house/ownership type. There was no significant relationship between the letter type seen by the householder and the number of enquiries about the scheme, $\chi 2 = 4.94$ (2), $p = 0.075$, Cramer's V = 0.032. Table 1 shows the percentage of householders who enquired by letter type and also broken down by type of house and ownership.

Table 1. Percentages of households who enquired about the solid wall scheme by; type of letter, house and ownership. (* the ownership of six homes was unknown; ex Council/HA—ex council owned or housing association owned homes which are now privately owned).

Letter Type								
Text only letter (STD) (n = 1580)			House without insulation (PRB) (n = 1569)			House with and without insulation (PRB + SOL) (n = 1593)		
2% (n = 32)			1.8% (n = 28)			1.1% (n = 17)		
House								
Victorian (n = 461)		Concrete (n = 1119)	Victorian (n = 419)		Concrete (n = 1150)	Victorian (n = 451)		Concrete (n = 1142)
1.1%		2.4%	2.4%		1.6%	0.7%		1.2%
Ownership *								
Owner-occupied (n = 1071)	Rented (n = 48)	Ex Council/HA (n = 459)	Owner-occupied (n = 1062)	Rented (n = 47)	Ex Council/HA (n = 459)	Owner-occupied (n = 1052)	Rented (n = 64)	Ex Council/HA (n = 474)
1.6% (n = 17	2.0% (n = 1)	3.1% (n = 14)	2.2% (n = 23)	2.1% (n = 1)	0.9% (n = 4)	1.2% (n = 12)	0.0% (n = 0)	1.1% (n = 5)

Of the householders living in concrete houses, 1.7% called up to enquire about the scheme, whilst, 1.4% of the Victorian home owners enquired, but there was no relationship between enquiries and type of house, $\chi 2$ (1) = 0.85, $p = 0.443$, Cramer's V = 0.013.

With an enquiry rate of 1.6% of householders in owner occupied homes, 1.3% of those in the rented sector and 1.7% of householders in ex council/housing association homes, there was no significant relationship between enquiries and ownership type, $\chi 2$ (2) = 0.14, $p = 0.932$ Cramer's V = 0.005.

3.2. Qualitative Study

Fifteen householders were included in this additional exploratory small study, of which seven were males, and the majority of participants were in the 40–50 age bracket. Fourteen of those preferred the PRB + SOL letters which contained the 'with and without insulation' images, with only one participant preferring the PRB letter. Five participants expressed that the PRB + SOL letters attracted their attention most. These were felt to 'communicate heat loss' in that the 'difference' between the no insulation and insulation house was immediately apparent. One of the 14 householders found the PRB + SOL letters difficult to interpret, whilst 13 of the participants had no difficulty in interpreting the 'dark house' (see Figure 2a–e for the images) as the one with the insulation in place. Six participants felt the PRB + SOL images were most informative. In contrast, participants felt that the STD letter would not attract their attention to the issue of insulating the walls, or to the scheme. In fact, four participants reported spontaneously that this letter was the most likely of the three to 'go straight into the bin'. The PRB letter was viewed as being more confusing than the two images. Four people specifically reported that it was less easy to understand the meaning of the one image, how to interpret it, and which aspects of the image represented hot and cold.

4. Discussion

This study investigated whether adding thermal images to letters inviting householders to take up an offer to install solid wall insulation would lead to an increase in the number of enquiries about the scheme. The letters were either a text only standard letter, a letter containing a thermal image of a 'house like yours' without insulation (the 'problem') or a letter containing two images comparing 'a house like yours' with and without insulation (the 'problem' and 'solution'). Adding images to a standard letter in a mailshot approach did not lead to an increase in householder enquiries about an offer to install solid wall insulation. Householders who saw letters with thermal images representing the problem (a house leaking energy in to the street) and/or representing the consequence of installing solid wall insulation were no more likely to enquire about the solid wall insulation scheme than those who were sent the text only letters. Including the images seemed to slightly suppress the interest in the scheme, although the analysis found that this small difference in the low response rates was not significant. These results contrast with the results found when inserting images in to car tax demand letters and are in contrast to previous research using personalised/tailored thermal images as an antecedent intervention to encourage energy efficiency actions [54].

A possible reason for the null effect could be that the images were confusing or difficult to interpret. The responses in the study do not support a difficulty in understanding. The results of the qualitative study suggest that householders did understand the information conveyed by the thermal images. Householders reported the 'with and without insulation' thermal images as being more informative and better able to communicate the message of heat loss than the 'without insulation' and no image letter. They also understood the differential effect of no insulation vs. in place insulation from viewing the letters and commented that the image immediately attracted attention to the topic of energy efficiency whereas the control letter (with no images) was more likely not to have been read. A similar study involving a cohort of over 980 householders tested their understanding of tailored thermal images and non-tailored thermal images of homes and found that householders rated non-tailored thermal images as understandable [53]. However, our qualitative study did not measure the householders' specific knowledge/comprehension of the images (by condition) in the letter context. This could have been achieved by conducting a short study containing a series of very specific knowledge questions related to the letters and the images (such as 'What does it mean if a house is darker in the image?'). If replicating the study, pre-intervention piloting could include an enhanced and specific knowledge check.

The research question rested on the premise that visualising the 'problem' (heat egress) and the 'solution' (solid wall insulation) for householders (at a time contingent with an offer to provide and possibly fund the work) would enhance the householders understanding of the efficacy of the energy efficiency action, thereby improving the rate of enquiry about the scheme. There are various other potential reasons for this null effect. We know that images can affect the beliefs of the viewer. In Vancouver, local residents reported an increased belief in the efficacy of mitigating actions, after seeing images of future local landscapes [40]. Furthermore, incorporating images of 'your car' into a car tax demand letter increased the payment rate of the tax [58]. We know that intensive tailored thermal imaging interventions can motivate energy efficiency actions [48]. In such an intervention, thermographers visit the home with an infrared camera and image very specific parts of the householders' building (doors, windows, and draughts at lofts, for example). This type of tailored visual can help householders to overcome psychological barriers to taking up energy saving behaviours [51]. However, the less intensive letter presentation of thermal images in the present trial may not have been enough to overcome the internal psychological and external contextual barriers surrounding the more complex set of actions required to set up the installation of solid wall insulation [3,68,69]. Previous research also has not targeted solid wall insulation specifically but simply recorded a range of actions following the intervention (most common actions were draught proofing, loft insulation, etc.). Thus, next to not being personalised enough, perhaps the specific

target action does not respond to thermal imaging interventions. It is known that installing wall insulation is an energy efficiency measure which is difficult to prompt or induce [18]. Future research should investigate whether a personalised thermal imaging intervention is able to change interest in solid wall home insulation specifically.

However, the null finding also suggests that a behavioural intervention may work in one context but not translate to a different context. In the energy domain, this has already been observed in other studies. Research on the design of energy display interfaces suggested that numerical information was the preferred way for people to observe current, changing energy use [70]. However, in the context of energy information in the 'live' kitchen environment in student flats, the efficacy of numerical information over other forms of display (ambient faces and analogue dials) was lost [71]. The context of an intervention is important; different contexts have different barriers to action [60] and will afford specific behaviours more than others. Therefore, the impact of an intervention emerges out of the intervention set within its context [72]. An individual's response to images is also likely to be affected by the context. When householders saw thermal images showing draughts and missing insulation in their own home, they were more likely to take simple energy saving actions compared to householders who received an energy audit and home visit [48,73]. So, although householders responded well by taking simple, inexpensive draught proofing measures in their own home after they saw a draught, this persuasive effect was lost set in the context of letters offering an external wall insulation scheme. However, taking one off energy efficiency measures such as installing solid wall insulation is a complex behaviour, with multiple factors influencing the householders' decision [12,18].

Limitations

The extremely low response rate could indicate other issues. We know from previous communications that only 0.05% of householders responded to a mailshot leaflet announcing a loft clearance scheme [10] so the take up of this type of offer has been low. Overall, 1.62% responded in the present trial. Partly this could be because the target sample had already received the standard communication, eliminating those who were more willing to consider the programme. Indeed, Plymouth City Council had recorded a response rate of 1 in 8 (12.5%) to previous, standard letters announcing the solid wall insulation scheme. It is also possible that the timing contributed to a low response. Letters were sent out up until April, when many households switch off the central heating and stop being concerned about the cold. An intervention at the start of the heating season would meet a different motivational state (and indeed our previous research on thermal imaging was timed accordingly).

The advantage of this randomized control trial was that it afforded an opportunity to test an intervention with a very large sample size. However, it was not easy to pretest the intervention or to follow up the results with a more intensive, qualitative approach. Future studies can be designed so that images are piloted using qualitative measures to gauge the reaction of the householder to the stimuli, using psychological measures. Piloting could also test the householder comprehension of the images and the letter contents, using a series of very specific knowledge questions.

Finally, the letters were addressed to the householder in a closed envelope. Apart from some qualitative data from our own exploratory second study we have no firm evidence, but it is conceivable that a large percentage of householders discarded such a letter and thus was never exposed to the images, which were the key ingredient of this intervention. This is in contrast to, for example, the car tax letter trial, where the letter was addressed to the named owner of the vehicle. This limitation is unlikely to have affected one condition more than another, but it would have led to overestimating the sample size of those actually being exposed to the intervention. It would be desirable for future research to use envelopes addressed with names, or to make the visualisation more directly accessible, for example by using larger format postcards or a door hanger type design [74]. One future strategy to inform whether and how the images were seen in the letter could be to collect data

on psychological variables before and after the intervention [75]. For example, perceived efficacy of the solid wall insulation measure, recall, or motivation measures can be before and after the letters were sent, and would provide insight into whether the householder had been exposed to the images.

5. Conclusions

Using visualisation for communicating complex or abstract issues holds great promise in areas as diverse as health, climate change and energy. However, the present large-scale randomised controlled trial with householders in Plymouth, UK showed no difference in enquiry rates for mass communication letters with and without thermal imaging visualisations. These null results are nevertheless important to inform the feedback loop for the next round of research on interventions. They also prevent future researchers repeating the same design and add to the nuanced picture of what does, and importantly, does not work as a behavioural intervention. It also appears that external solid wall insulation specifically is an action difficult to motivate. Additional potential reasons for the null effect include the timing of the intervention (into late spring), the format of the communication (letter addressed 'to the householder') and the sample (people who had been contacted previously without success). Future research should trial formats that can tailor the images and make visualisations directly accessible.

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